Name:

Student Number:

Note: Closed book. 50 minutes. 6 pages. 4 questions. 48 marks. All Scheme and ML programs should be written in good functional-programming style. Write all answers on the test booklet, using the back of pages if necessary. Good luck!

If you do not know the answer to a question, and you write “I don’t know”, you will receive 20% of the marks of that question. If you just leave a question blank with no such statement, you get 0 marks for that question.
1. (12 marks) Define a scheme function \( \text{maxPos} \ E \) that takes a nested list \( E \) as input and returns the largest positive number mentioned in \( E \). If \( E \) contains no positive numbers, then return 0. For example,

\[
\begin{align*}
(\text{maxPos} \ ' (1 \ a \ -2 \ b \ c \ 3 \ 4)) & \Rightarrow 4 \\
(\text{maxPos} \ ' (1 \ (a \ -2) \ (b \ (c \ (7 \ 5) \ ())))) & \Rightarrow 7 \\
(\text{maxPos} \ 13) & \Rightarrow 13 \\
(\text{maxPos} \ ' (a \ b \ c)) & \Rightarrow 0 \\
(\text{maxPos} \ ' (a \ (-6 \ c))) & \Rightarrow 0
\end{align*}
\]
2. (12 marks total) Consider the following pair of Scheme functions:

\[
\begin{align*}
\text{(define (f X)} & \text{ (cond ((null? X) X)} \\
& \text{ (else (g (f (cdr X)) (cons (car X) \text{ '()})))}) \\
\text{(define (g X Y)} & \text{ (cond ((null? X) Y)} \\
& \text{ (else (cons (car X) (g (cdr X) Y))))})
\end{align*}
\]

(a) (5 marks) In ten words or less, describe what \text{g} does.
(Only the first ten words of your answer will be graded.)

(b) (1 mark) Give an example of what \text{g} does.

(c) (5 marks) In ten words or less, describe what \text{f} does.
(Only the first ten words of your answer will be graded.)

(d) (1 mark) Give an example of what \text{f} does.
3. (12 marks total)

(a) (8 marks) What is the type of each of the following ML functions (2 marks each):

\begin{verbatim}
fun f1(X,Y,Z) = (1+X+Y,Z);

fun f2 [] = []
    | f2((X,Y)::L) = (Y,X)::f2(L);

fun f3(g,X,h,Y) = h(X,g(Y));

fun f4(f,g,h) = (fn X => h(g(f X)));
\end{verbatim}
(b) (2 marks) In 25 words or less, describe what \( f_2 \) does. (Only the first 25 words of your answer will be graded.) Give an example to illustrate.

(c) (2 marks) In ten words or less, describe what \( f_4 \) does.
(Only the first ten words of your answer will be graded).
4. (12 marks total)

(a) (2 marks) Define `employee` to be a named type for records, where each record has four fields: `id`, `name`, `age`, `salary`. These four fields contain an integer, a string, an integer, and a real number, respectively.

(b) (10 marks) Define an ML function `avgSal(L)` that takes a list `L` of employee records, and returns the average salary of the employees. If `L` is empty, then return a negative number. For full marks, you should use pattern matching whenever possible.